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SUCTION DEVICE AND NOZZLE DEVICE

BACKGROUND

The present invention relates to a suction device which comprises a nozzle for sucking in the outside air and is capable of expelling a fluid over an object, and this invention also relates to a nozzle device capable of sucking in the outside air and expelling a fluid over the object.

Conventionally, it is relatively difficult to remove and clean unwanted matter, such as dirt, adhering to objects (or cleaned objects) such as walls, ceilings, floors, bathroom surfaces, furniture, equipment such as ventilating fans or air conditioners, various kinds of manufacturing machines, and vehicles such as cars, motorcycles, or bicycles. Particularly, it is very difficult to wipe or wash off grease adhering to these cleaned objects with normal cleaning fluid.

Accordingly, a cleaning device that cleans dirt off with a spraying force of a cleaning fluid sprayed on the dirt adhering to the cleaned object has recently been suggested. Moreover, any unwanted matter that cannot be cleaned off by the cleaning device is removed by, for example, further scrubbing the dirt with a cloth, a scrubbing brush, a mop or the like. However, when this cleaning device is used to clean off the dirt adhering to horizontal surfaces such as floors, the cleaning fluid sprayed over the floors or other horizontal surfaces and the dirt removed by the cleaning fluid (the "sprayed cleaning fluid" and the "dirt removed by the cleaning fluid" may be collectively and simply referred to as "wastewater"

below) remain on the floors or other horizontal surfaces. Accordingly, it is necessary to further wipe them with, for example, a cloth.

Moreover, when the dirt adheres to vertical surfaces such as walls, or ceilings or the like, the cleaning fluid sprayed over them and the dirt removed by the cleaning fluid run down or fall. Therefore, it is necessary to wipe the wastewater with, for example, a cloth. If the wastewater runs or falls onto any clean part of the vertical surfaces or ceilings, it is also necessary to clean this part. Furthermore, if plants, furniture, electric appliances or the like are placed beside the walls or under the ceilings to be cleaned, and if the cleaning fluid runs or drips onto them, the problems of killing the plants, or damaging the furniture or the failure of the electric appliances may result. Accordingly, in this case, when cleaning the dirt off the walls or ceilings, it is necessary to cover the plants, furniture, electric appliances or the like with, for example, a vinyl sheet so that the wastewater will not drip onto them directly.

As the number of elderly persons, who need care because they are bedridden or suffer from dementia, has been increasing sharply recently, the care of such persons, particularly the disposal of excrement, has become a very important issue. Diapers are generally used for the disposal of excrement of the elderly persons in the above-described conditions. Specifically speaking, the disposal of excrement is now conducted by changing diapers regularly or once they are soiled. However, just changing diapers will leave residual excrement on the body, giving rise to problems of sanitary management. Accordingly, it is still necessary to remove the residual excrement on the body when changing diapers.

Such a task has been conducted by using commercially available cleaning items or hot wet towels. Namely, the current way of removing the residual excrement is for a caregiver to directly wipe a feculent part of the body of an elderly person, that is, the residual excrement on the body. However, the residual excrement on the body often solidifies by the time of changing diapers and much time and labor is required for the removal of the excrement by hand.

Therefore, the applicant of this invention has suggested, in Japanese Patent Laid-Open (Kokai) Publication No. 2001-161762, a suction device capable of easily sucking in and removing the above-described matter, such as dirt.

Moreover, Japanese Patent Laid-Open (Kokai) Publications No. 2001-245952, No. 2001-245953, No. 2001-261968, No. 2001-276172, and No. 2001-299903 disclose various nozzle structures which are connected to the suction device as described above and are used to suck in the matter.

However, the above-mentioned nozzle structures disclosed in Japanese Patent Laid-Open (Kokai) Publications No. 2001-245952, No. 2001-245953, No. 2001-261968, No. 2001-276172, and No. 2001-299903 are characterized in that when the fluid is expelled out of the nozzle during the suction operation and even if the nozzle is moved away from a surface, to which the matter to be sucked is adhering, the fluid will not be scattered about. However, the nozzle structures are complicated in order to realize the above-described feature.

SUMMARY

The present invention aims to improve the above-described conventional suction devices and nozzle devices. It is the object of this invention to provide a suction device and a nozzle device, whose structures are simple, which can cause a fluid to be automatically expelled out of a nozzle toward an object by placing the nozzle close to or in contact with the object when conducting a suction operation, and which can automatically stop the fluid from ejecting out of the nozzle when the nozzle is moved away from the object.

In order to achieve the above-described object, this invention provides a suction device comprising a nozzle for sucking in the outside air, wherein the suction device is structured in such a manner that: a fluid nozzle is provided within the nozzle in order to expel a fluid toward the opening of the nozzle; when the opening of the nozzle is unobstructed, the outside air being sucked into the nozzle through its opening causes the fluid being expelled out of the fluid nozzle to be pushed back and sucked into the nozzle from its base end without the fluid being ejected out of the nozzle; and when the amount of the outside air sucked into the nozzle is decreased by placing the opening of the nozzle close to or in contact with an object, the fluid expelled out of the fluid nozzle overcomes the outside air and thereby the fluid is ejected toward the object, and the fluid that has struck the object is sucked in together with the outside air into the nozzle.

Merely by simple operation of moving the nozzle close to the object or causing the nozzle to contact the object, the suction device having the

above-described structure can cause the fluid to be automatically expelled out of the nozzle and can also suck in the fluid that has struck the object. The suction device can also stop the fluid ejecting out of the nozzle merely by moving the nozzle away from the object.

It is possible to form, in the vicinity of the opening of the nozzle, at least one small hole capable of introducing the outside air into the nozzle.

By forming such a small hole, it is possible to introduce the outside air through the small hole into the nozzle even if a negative pressure is formed inside the nozzle by causing the nozzle to closely contact the object. Accordingly, it is possible to smoothly move the nozzle in relation to the object and to recover the wastewater smoothly.

The suction device of this invention can be structured in such a manner that a fluid injection hole of the fluid nozzle is located at a position recessed from the opening of the nozzle.

Concerning the suction device of this invention, either the amount of the outside air or the pressure of the fluid, or both of them, can be adjusted so that: when the opening of the nozzle is unobstructed, the pressure of the outside air corresponding to the amount of the outside air sucked into the nozzle exceeds the pressure of the fluid expelled out of the fluid nozzle in an area between the opening of the nozzle and the fluid injection hole; and when the amount of the outside air sucked into the nozzle is decreased, the pressure of the fluid expelled

out of the fluid nozzle exceeds the pressure of the outside air that corresponds to the amount of the outside air sucked into the nozzle in the area between the opening of the nozzle and the fluid injection hole.

Moreover, regarding the suction device of this invention, the cross-section area of the opening of the nozzle can be determined based on the pressure of the fluid expelled out of the fluid nozzle, thereby controlling the amount of outside air sucked into the nozzle.

Concerning the suction device of this invention, the distance between the opening of the nozzle and the fluid injection hole can be determined based on the pressure of the outside air corresponding to the amount of outside air sucked into the nozzle, as well as the pressure of the fluid expelled out of the fluid nozzle.

Moreover, the suction device of this invention can be structured in such a manner that when the amount of outside air sucked into the nozzle is decreased, the fluid expelled out of the fluid injection nozzle is ejected toward the object and the matter to be sucked, which is adhering to the object, so that the matter, together with the outside air and the fluid that has struck the object and the matter, can be sucked into the nozzle.

Furthermore, concerning the suction device of this invention, brushes can be placed in an attachable and detachable manner at the top end of the opening side of the nozzle. In addition to the aforementioned advantageous effects of the suction device, such attachment of the brushes to the top end of the opening

side of the nozzle promotes the removal of the matter, such as dirt that is adhering to the object, by scraping and scrubbing the matter when expelling the fluid onto the matter to remove it.

Regarding the suction device of this invention, an elastic member can also be placed in an attachable and detachable manner at the top end of the opening side of the nozzle.

The present invention further provides a nozzle device comprising: a nozzle connected to a suction device; and a fluid nozzle placed within the nozzle and connected to a fluid injection device in order to expel a fluid toward the opening of the nozzle; wherein the nozzle device is structured in such a manner that: when the opening of the nozzle is unobstructed, the outside air sucked into the nozzle through its opening causes the fluid expelled out of the fluid nozzle to be pushed back and sucked into the nozzle from its base end without the fluid being ejected out of the nozzle; and when the amount of the outside air sucked into the nozzle is decreased by placing the opening of the nozzle close to or in contact with an object, the fluid expelled out of the fluid nozzle overcomes the outside air and is thereby ejected toward the object, and the fluid that has struck the object is sucked together with the outside air into the nozzle.

The nozzle device having the above-described structure can automatically expel the fluid toward the object merely by moving the nozzle close to the object or causing the nozzle to contact the object. It is also possible to automatically stop the fluid ejecting out of the nozzle by moving the nozzle away from the

object.

Concerning the nozzle device of this invention, it is possible to form, in the vicinity of the opening of the nozzle, at least one small hole that can introduce outside air into the nozzle.

Moreover, the nozzle device of this invention can be structured in such a manner that a fluid injection hole of the fluid nozzle is located at a position recessed from the opening of the nozzle.

Regarding the nozzle device of this invention, brushes can be placed in an attachable and detachable manner at the top end of the opening side of the nozzle.

Furthermore, regarding the nozzle device of this invention, an elastic member can be placed in an attachable and detachable manner at the top end of the opening side of the nozzle.

The suction device of this invention has a simple structure. When conducting the suction operation, the suction device can cause the fluid to be automatically expelled out of the nozzle toward the object by means of a simple operation of placing the nozzle close to or in contact with the object, and can suck in the fluid that has struck the object. Moreover, the suction device has such an advantageous effect that it is possible to automatically stop the fluid ejecting out of the nozzle merely by moving the nozzle away from the object.

The nozzle device of this invention has a simple structure. When conducting the suction operation, the nozzle device can automatically expel the fluid toward the object by means of a simple operation of placing the nozzle close to or in contact with the object, and can suck in the fluid that has struck the object. Moreover, the nozzle device has such an advantageous effect that it is possible to automatically stop the fluid ejecting out of the nozzle by merely moving the nozzle away from the object.

DESCRIPTION OF DRAWINGS

Fig. 1 is a schematic view of a suction device on which a nozzle device is mounted according to Embodiment 1 of this invention.

Fig. 2 is a perspective view of the nozzle device of Fig. 1.

Fig. 3 is an enlarged sectional view of the principal part of the nozzle device shown in Fig. 1, where the suction device is activated, and the opening of the nozzle device is unobstructed.

Fig. 4 is an enlarged sectional view of the principal part of the nozzle device shown in Fig. 1, where the suction device is activated, and the opening of the nozzle device is closed by an object.

Fig. 5 is a perspective view of a nozzle device according to another

embodiment of this invention.

Fig. 6 is a sectional view of an attachment attached to the top end of the nozzle device according to another embodiment of this invention.

Fig. 7 is a sectional view of a nozzle device according to Embodiment 2 of this invention, wherein the suction device is activated and the opening of the nozzle device is unobstructed.

Fig. 8 is a sectional view of the nozzle device of Fig. 7, wherein the suction device is activated and the opening of the nozzle device is closed by an object.

Fig. 9 is a front view of the nozzle device of Fig. 7.

Fig. 10 is a sectional view of the nozzle device as taken along line X-X of Fig. 9

DETAILED DESCRIPTION

Preferred embodiments of the suction device and the nozzle device according to this invention are explained below with reference to the attached drawings. The following embodiments are described for purposes of illustration of this invention, and this invention is not limited to these embodiments. Therefore, this invention can be implemented in various manners unless such

variations depart from the gist of the invention.

Embodiment 1

Fig. 1 is a schematic view of a suction device on which a nozzle device is mounted according to Embodiment 1 of this invention. Fig. 2 is a perspective view of the nozzle device of Fig. 1. Fig. 3 is an enlarged sectional view of the principal part of the nozzle device shown in Fig. 1, where the suction device is activated, and the opening of the nozzle device is unobstructed. Fig. 4 is an enlarged sectional view of the principal part of the nozzle device shown in Fig. 1, where the suction device is activated, and the opening of the nozzle device is closed by an object.

Embodiment 1 is explained below by referring to an example in which the fluid is water and the object is a wall.

As shown in Figs. 1 to 4, a suction device 1 of Embodiment 1 comprises a main suction device 100 and a nozzle device 10 detachably attached to the main suction device 100.

Referring to Fig. 1, the main suction device 100 comprises: a main tank 120 capable of containing water 200 as the fluid; a filter unit 121 which is connected to the inside of the main tank 120 and filters the water 200 contained in the main tank 120; a pump 132 which is connected to the filter unit 121 and pumps up the water 200 filtered by the filter unit 121; a fluid supply tube 102

which is connected to the pump 132 and externally supplies the water 200 pumped up by the pump 132; a suction hose 101 which is connected to the main tank 120 and recovers the water 200 sprayed onto a wall 150, together with the outside air 300, into the main tank 120; a fan motor 141 which is connected to the main tank 120 and sucks in the air (outside air) contained in the main tank 120; a heater 160 which is connected to the main tank 120 and controls the temperature of the water 200 supplied through the filter unit 121 from the main tank 120; a control panel 170 for controlling the operation of the main suction device 100; and a base 180 capable of moving with all the described components mounted thereon.

The main tank 120 has a generally cylindrical shape which can be hermetically sealed, whose generally central part is hollow, and which possesses enough strength to withstand the suction by the fan motor 141. On the top face (or ceiling plane) of the main tank 120, a separator 143 is provided to separate a gas-liquid mixture introduced from the main tank 120 into a gas and a liquid according to the cyclone principle. The separated gas is sucked by the fan motor 141 via a duct 130. This structure prevents water drops from entering the fan motor 141. On the wall surface of the main tank 120, the following components are mounted: a level gauge 123 by which the volume of the water 200 contained in the main tank 120 can be visually checked; the fluid supply tube 102; and hooks 124 for hanging the suction hose 101.

The filter unit 121 is connected via a connecting hose 128 to the main tank 120. This filter unit 121 comprises: a tank 126 into which the water 200

contained in the main tank 120 is supplied via the connecting hose 128; and a filter 127 which is placed within the tank 126 and filters the water 200. This filter unit 121 is connected to the pump 132.

The pump 132 is used to pump up the water 200, which is contained in the filter unit 121 and is filtered by the filter 127, and then to supply the water 200 from the top end of the fluid supply tube 102 to a fluid nozzle 12 of the nozzle device 10, described later in detail. This pump 132 is connected to a pressure control unit 133 for controlling the pressure (water pressure) of the water 200 supplied to the fluid nozzle 12. This pressure control unit 133 can control the pressure of the water (hot water) 200, as desired, at the time of expelling the water 200 toward the wall 150.

The pressure control unit 133 may be set so as to switch the pressure of the water 200 to be supplied to the fluid nozzle 12 among several stages, for example, "strongest," "strong," "slightly strong," "moderate," "slightly weak," "weak," and "weakest," or an even more gradual control operation may be performed. It is possible to set the pressure control unit 133 so that the set pressure will be maintained unless it is intentionally changed. The operation of the pressure control unit 133 may be conducted by using a switch (not shown in the drawing) on the control panel 170 or by remote control with, for example, a controller.

The base end of the fluid supply tube 102 is connected to the heater 160 and the pump 132, and then to the filter 127 of the filter unit 121. The top end of

the fluid supply tube 102 can be connected to the fluid nozzle 12 of the nozzle device 10 as described later in detail. This fluid supply tube 102 is secured to the suction hose 101 with fasteners 134.

The base end of the suction hose 101 is connected to the main tank 120, and is constructed in such a manner that the suction by the fan motor 141 causes the suction hose 101 to suck in the outside air 300 into the main tank 120. The top end of the suction hose 101 can be connected to the nozzle 11 of the nozzle device 10 as described later in detail.

The fan motor 141 is connected to a suction control unit 142 for controlling the degree of vacuum (or suction force) of the fan motor 141. This suction control unit 142 can control, as desired, the sucked amount (or air volume) of the outside air 300 sucked through the opening 13 of the nozzle 11 attached to the top end of the suction hose 101. By controlling the suction force, the suction control unit 142 can achieve a balance between the pressure of the outside air 300 corresponding to the amount of the outside air sucked-in from the top end of the nozzle 11, and the water pressure of the ejecting water 200, and can prevent the water 200 from being externally discharged from the opening 13 of the nozzle 11 by means of the pressure of the sucked-in outside air 300.

At the top end of the nozzle device 10, the opening 13 capable of sucking in the outside air 300 is formed. The nozzle device 10 comprises the nozzle 11 whose base end can be connected to the suction hose 101; and the fluid nozzle 12 which is located inside the nozzle 11 and expels the water 200 toward the

opening of the nozzle 11.

The nozzle 11 comprises: a large-diameter part 14 in a generally cylindrical shape that can be connected to the suction hose 101; and a small-diameter part 15 in a generally cylindrical shape that is connected to the large-diameter part 14 and has a smaller diameter than that of the large-diameter part 14. The large-diameter part 14 has a hollow structure, and the fluid nozzle 12 is placed in this hollow section. The small-diameter part 15 has a hollow section connected to the hollow section of the large-diameter part 14, and is capable of causing the water 200 being expelled out of the fluid nozzle 12 to eject out of the nozzle 11 through the opening 13 formed at its top end.

Concerning Embodiment 1, the inside diameter of the small-diameter part 15, that is, the diameter of the opening 13 ("ID" in Fig. 3) was set to 10 mm, and the length of the small-diameter part 15 ("SL" in Fig. 3) was set to 110 mm. Moreover, at the top end of the small-diameter part 15 (in the vicinity of the opening 13), a small hole which can introduce the outside air 300 into the nozzle 11 is formed. Concerning Embodiment 1, the diameter of this small hole 16 ("SD" in Fig. 3) was set to 1.5 mm.

At the top end of the fluid nozzle 12, an injection hole 17 for expelling the water 200 is formed, and the base end of the fluid nozzle 12 can be connected to the fluid supply tube 102. The injection hole 17 faces the hollow section of the small-diameter part 16, so that the water 200 being expelled out of the injection hole 17 passes through the hollow section of the small-diameter part 15 and

ejects out of the opening 13.

Regarding Embodiment 1, the position of the fluid nozzle 12 was set so that the distance between the injection part 17 and the boundary between the large-diameter part 14 and the small-diameter part 15 ("ML" in Fig. 3) would become 10 mm. The hole diameter of the injection part 17 was set to approximately 0.5 mm.

The following description is about the detailed working of the suction device 1 according to Embodiment 1.

The nozzle 11 of the nozzle device 10 is first connected to the top end of the suction hose 101 of the main suction device 100. The fluid nozzle 12 of the nozzle device 10 is connected to the top end of the fluid supply tube 102. The nozzle device 10 is then attached to the main suction device 100.

Subsequently, a specified amount of the water 200 is contained in the main tank 120, and the control panel 170 is then operated to activate the fan motor 141. Concerning Embodiment 1, the suction control unit 142 was used to set the degree of vacuum of the fan motor 141 to approximately 19 kPa. The activation of the fan motor 141 causes the outside air 300 to be sucked into the nozzle 11 through its opening 13 at the top end of the suction hose 101. At this point, the amount of the outside air sucked into the nozzle 11 through its opening 13 is approximately 1.0 m^3/min. This suction of the outside air 300 causes the air in the main tank 120 to be introduced into the separator 143. Even if the

water 200 is mixed with the air at this moment, the gas (air) will be separated from the liquid (water 200) within the separator 143 according to the cyclone principle, and the water 200 will not be sucked into the fan motor 141. The outside air (or air) sucked by the fan motor 141 passes through the duct 130 and then through the fan motor 141, and exits via a specified exhaust port.

At the same time, the control panel 170 is operated to activate the pump 132. The activation of the pump 132 causes the water 200 contained in the filter unit 121 to be pumped up, and the heater 160 keeps the water 200 at a desired temperature. The water (hot water) 200 kept at a desired temperature is then supplied via the fluid supply tube 102 to the nozzle 12. Concerning Embodiment 1, the pressure control unit 133 is used to set the water pressure of the pump 132 to approximately 0.3 MPa. At this point, the flow rate of the water 200 expelled out of the injection hole 17 of the fluid nozzle 12 is approximately 50 liters/hour.

In this state where the opening 13 of the nozzle 11 is unobstructed (see Fig. 3), that is, where the nozzle 11 is placed away from the wall 150, the outside air 300 being sucked into the nozzle 11 through its opening 13 collides with the water 200 being expelled out of the fluid nozzle 12 in the area between the injection hole 17 of the fluid nozzle 12 and the opening 13 of the nozzle 11. The outside air 300 overcomes the water 200 being expelled out of the fluid nozzle 12, and the water 200 will not be ejected out of the opening 13 of the nozzle 11. Instead the water 200, together with the outside air 300, is sucked into the main tank 120 and recovered. Accordingly, it is not necessary to provide the nozzle device 10 with any complicated structure, such as a shielding plate as applied to

conventional devices, in order to block the ejection of the water 200. It is possible to block the ejection of the water 200 with the sucked-in outside air 300 so that the water 200 expelled out of the fluid nozzle 12 will not be ejected out of the opening 13 of the nozzle device 11. Therefore, it is possible to simplify the structure of the nozzle, to lower the failure rate, and to inexpensively manufacture the nozzle.

When the opening 13 of the nozzle 11 is placed closed to or in contact with the wall 150 (see Fig. 4) while maintaining the degree of vacuum of the fan motor 141 and the water pressure of the pump 132, the amount of the outside air sucked into the nozzle 11 decreases as compared to that when the opening 13 of the nozzle 11 is unobstructed. At this point, the amount of the outside air sucked into the nozzle 11 is approximately 0.05 m^3/min. Even if the opening 13 is closely pressed against the wall 150, the outside air 300 will be introduced into the nozzle 11 via the small hole 16. Accordingly, it is possible to move the nozzle device 10 smoothly and to recover the wastewater smoothly. A decrease in the amount of the outside air sucked into the nozzle 11 causes the water 200 being expelled out of the fluid nozzle 12 to overcome the outside air 300 being sucked into the nozzle 11 and to be ejected toward the wall 150. Then, the water 200 that has struck the wall 150 is sucked into the main tank 120 and recovered, together with the outside air 300, via the suction hose 101.

If dirt or the like adheres to the wall 150, the dirt will be removed by the water 200 being expelled on the wall 150 and will be sucked into the main tank 120 and recovered, together with the water 200 and the outside air 300, via the

suction hose 101. Therefore, it is possible to suck in and remove the dirt easily and securely without causing the water 200 being expelled on the wall 150 to run down or drip onto a user's clothes, bedding, floors or the like making them wet.

As a result of the above-described action, both the recovered liquid and the clean water 200 that has been housed from the beginning will be put in the main tank 120. The operation of the pump 132 causes the water 200 that has been housed in the main tank 120 and the water 200 recovered into the main tank 120 to be supplied to the filter unit 121, where the mixture is filtered by the filter 127, and the filtered water 200 is then supplied again through the fluid supply tube 102 to the fluid nozzle 12.

If the opening 13 of the nozzle 11 in the above condition is moved away from the wall 150 (that is, the opening 13 of the nozzle 11 is unobstructed), the amount of the outside air sucked into the nozzle 11 through its opening 13 increases again. In the area between the injection hole 17 of the fluid nozzle 12 and the opening 13 of the nozzle 11, the sucked-in outside air 300 collides with the water 200 being expelled out of the fluid nozzle 12. As a result, the outside air 300 overcomes the water 200 being expelled out of the fluid nozzle 12, and the water 200 will not be ejected out of the opening 13 of the nozzle 11, but will be sucked into the main tank 120 and recovered, together with the outside air 300.

Concerning Embodiment 1, the case in which water (hot water) is used as the fluid has been described. However, the fluid is not limited to water, and any fluid can be selected as desired, depending on the purpose of use. Examples of

the fluid include water vapor, alkaline cleaning solvents or much stronger alkaline cleaning solvents, chlorine cleaning solvents such as bleaching agents or fungicides, neutral detergents, alcohol disinfectants, beauty products (such as toners, cosmetic essence, or moisture lotions), or solutions or vapors containing aromatic essence. It is also possible to choose the temperature, spray amount, and other conditions of the fluid as appropriate, according to the type and purpose of use of the fluid.

Moreover, concerning Embodiment 1, the case in which the inside diameter (ID) of the small-diameter part 15, that is, the inside diameter of the opening 13 was set to 10 mm, and the length of the small-diameter part 15 was set to 110 mm has been described. However, the size of the small-diameter part 15 is not limited to the above-described size. Both the inside diameter (ID) and the length (SL), or either one of them, of the small-diameter part 15 can be decided, as desired, according to the water pressure of the water 200 being expelled out of the fluid nozzle 12, as long as the following results are obtained: when the opening 13 of the nozzle 11 is unobstructed, the outside air 300 being sucked into the nozzle 11 through its opening 13 can overcome the pressure of water 200 being expelled out of the fluid nozzle 12, and the water 200 can be sucked in together with the outside air 300 without the water 200 being ejected out of the opening 13 of the nozzle 11; and when the opening 13 of the nozzle 11 is placed close to or in contact with the wall 150 to cause the amount of the outside air sucked into the nozzle 11 to decrease, the water 200 being expelled out of the fluid nozzle 12 can overcome the pressure of the outside air 300 and is ejected toward the wall 150, and the water 200 that has struck the wall 150 can be

sucked in together with the outside air 300.

Furthermore, this invention has been described about the case in which the degree of vacuum of the fan motor 141 is set to become approximately 19 kPa and the water pressure of the pump 132 is set to become approximately 0.3 MPa. However, the degree of vacuum of the fan motor 141 and the water pressure of the pump 132 are not limited to the above settings, and can be decided as desired, as long as the following results are obtained: when the opening 13 of the nozzle 11 is unobstructed, the water 200 can be sucked in together with the outside air 300 without the water 200 being ejected out of the opening 13 of the nozzle 11; and when the opening 13 of the nozzle 11 is placed close to or in contact with the wall 150 to cause the amount of the outside air sucked into the nozzle 11 to decrease, the water 200 being expelled out of the fluid nozzle 12 can be ejected toward the wall 150, and the water 200 that has struck the wall 150 can be sucked up.

Furthermore, concerning Embodiment 1, the case in which the diameter of the small hole 16 was set to 1.5 mm has been described. However, the diameter of the small hole 16 is not limited to the above setting, and can be decided as desired as long as the following results are obtained: when the opening 13 of the nozzle 11 is closely pressed against the wall 150, the nozzle 11 can be moved smoothly in relation to the wall 150; and when the opening 13 of the nozzle 11 is unobstructed, the water 200 can be sucked in together with the outside air 300 without the water 200 being ejected out of the opening 13 of the nozzle 11; and when the opening 13 of the nozzle 11 is placed close to or in contact with the wall

150 to cause the amount of the outside air being sucked into the nozzle 11 to decrease, the water 200 being expelled out of the fluid nozzle 12 can be ejected toward the wall 150, and the water 200 that has struck the wall 150 can be sucked up. Similarly, it is also possible to set the number of the small holes 16 as desired.

Furthermore, if any material, such as a curtain that can allow passage of the outside air to some extent, or a wall that has a pattern-indented surface, is adopted as the object, even if the nozzle 11 is closely pressed against the material, a certain amount of the outside air will be introduced into the nozzle 11. Therefore, it is not always necessary to form the small hole 16.

Concerning Embodiment 1, the case in which the hole diameter of the injection part 17 was set to approximately 0.5 mm has been described. However, the hole diameter of the injection part 17 is not limited to the above setting, and can be decided as desired as long as the following results are obtained: when the opening 13 of the nozzle 11 is unobstructed, the water 200 can be sucked in together with the outside air 300 without the water 200 being ejected out of the opening 13 of the nozzle 11; and when the opening 13 of the nozzle 11 is placed close to or in contact with the wall 150 to cause the amount of the outside air sucked into the nozzle 11 to decrease, the water 200 being expelled out of the fluid nozzle 12 can be ejected toward the wall 150 and the water 200 that has struck the wall 150 can be sucked up.

Moreover, the shape and the size of the nozzle 11 are not limited to those

explained in Embodiment 1, and can be decided as desired, according to the part of the object, on which the nozzle 11 should be used, and according to the usage conditions. Fig. 5 shows an example in which the nozzle 11 is a hollow body that is slightly bent down. The shape of the fluid nozzle 12 can also be decided as desired, corresponding to the shape of the nozzle 11 as shown in Fig. 5.

Regarding another embodiment, as shown in Fig. 6, a cylindrical projection 21 with a small diameter may be further formed at the top end of the small-diameter part 15 of the nozzle, and an attachment 20 may be placed on the projection 21 in an attachable and detachable manner. The base end of the attachment 20 is formed as a fitting part 22 that can be detachably attached to the projection 21 of the nozzle 11. On the top-end surface of the fitting part 22, brushes 23 are implanted. Moreover, around the periphery of the fitting part 22, a rubber sheet 24 is attached so as to surround the brushes 23.

When the nozzle 11 is placed close to or in contact with the wall 150 and the water 200 is caused to be ejected to remove the matter such as dirt that is adhering to the wall 150, the brushes 23 are used to improve the removal of the matter by scraping or scrubbing.

The rubber sheet 24 serves to decrease the amount of the outside air sucked into the nozzle 11 when the nozzle 11 is placed close to or in contact with the wall 150. In other words, if the attachment only with the implanted brushes 23 were used, the outside air 300 would freely enter the nozzle 11 between the brushes 23 and, therefore, it would be difficult to decrease the amount of the

outside air sucked into the nozzle 11. However, if the periphery of the brushes 23 is surrounded with the rubber sheet 24, it is possible to easily decrease the amount of the outside air sucked into the nozzle 11. This rubber sheet 24 has moderate elasticity and flexibility and is thereby capable of following the movement of the brushes 23. Therefore, the rubber sheet 24 will not hinder the movement of the brushes 23 when scraping and scrubbing the matter.

Embodiment 2

Embodiment 2 of this invention is described below with reference to the relevant drawings.

Fig. 7 is a sectional view of a nozzle device according to Embodiment 2 of this invention, wherein the suction device is activated and the opening of the nozzle device is unobstructed. Fig. 8 is a sectional view of the nozzle device of Fig. 7, wherein the suction device is activated and the opening of the nozzle device is closed by an object. Fig. 9 is a front view of the nozzle device of Fig. 7.

The elements of Embodiment 2 which are similar to the elements described in Embodiment 1 are given the same reference numerals as in Embodiment 1, and any detailed description of such elements is omitted.

As shown in Figs. 7 to 9, a nozzle device 30 of Embodiment 2 is different from the nozzle device 10 of Embodiment 1 in the shape of a nozzle 31. At the

top end of this nozzle device 30, an opening 33 capable of sucking in the outside air 300 is formed. The nozzle device 30 comprises: the nozzle 31 whose base end can be connected to the suction hose 101; and the fluid nozzle 12 which is located within the nozzle 31 and ejects the water 200 toward the opening of the nozzle 31.

The nozzle 31 comprises: a cylindrical part 34 in a generally cylindrical shape which can be connected to the suction hose 101; and a fan-like part 35 in a generally fan shape which is connected to the cylindrical part 34 and whose diameter becomes gradually larger from its base end, which is connected to the cylindrical part 34, toward its top end.

The cylindrical part 34 has a hollow structure, and the fluid nozzle 12 is located in this hollow section. The top end of the fluid nozzle 12 extends to the base end of the fan-like part 35. The fan-like part 35 has a hollow section connected to the hollow section of the cylindrical part 34, so that the water 200 being expelled out of the top end of the fluid nozzle 12 can be ejected out of the opening 33 formed at the top end of the fan-like part 35. This opening 33 is generally rectangular as specifically shown in Fig. 9. Moreover, at the top end of the fan-like part 35 (in the vicinity of the opening 33), two small holes 16 which can introduce the outside air 300 into the nozzle 31 are formed.

Concerning Embodiment 2, the fan angle ("α" in Fig. 7) is set to 115 degrees, the length of the long side of the opening 33 ("LS" in Fig. 9) is set to 100 mm, and the length of the short side of the opening 33 ("SS" in Fig. 9) is set to 4

mm. The distance between the injection hole 17 of the fluid nozzle 12 to the opening 33 ("FL" in Fig. 7) is set to 45 mm. The diameter of the small hole 16 ("SD" in Fig. 7) is set to 1 mm.

The following description is about the detailed working of the suction device 1 according to Embodiment 2.

In the same way as in Embodiment 1, the nozzle 31 of the nozzle device 30 is first connected to the top end of the suction hose 101 of the main suction device 100. The fluid nozzle 12 of the nozzle device 30 is connected to the top end of the fluid supply tube 102. The nozzle device 30 is then attached to the main suction device 100.

Subsequently, the fan motor 141 is activated under the same conditions as in Embodiment 1 to suck in the outside air 300 from the opening 33 of the nozzle 31 attached to the top end of the suction hose 101. At the same time, the pump 132 is activated to supply the water (hot water) 200 via the fluid supply tube 102 to the fluid nozzle 12.

Concerning Embodiment 2, the pressure control unit 133 is used to set the water pressure of the pump 132 to approximately 3 kg/cm^2. At this point, the water 200 expelled out of the injection hole 17 of the fluid nozzle 12 formed an injection angle of 115 degrees and the injection rate was approximately 0.4 liters/min.

In this state where the opening 33 of the nozzle 31 is unobstructed (see Fig. 7), that is, where the nozzle 11 is placed away from the wall 150, just like in the case of Embodiment 1, the outside air 300 being sucked into the nozzle 31 through its opening 33 collides with the water 200 being expelled out of the fluid nozzle 12 in the area between the injection hole 17 of the fluid nozzle 12 and the opening 33 of the nozzle 31. The outside air 300 overcomes the water 200 being expelled out of the fluid nozzle 12, and the water 200 is not ejected out of the opening 33 of the nozzle 31. Instead, the water 200, together with the outside air 300, is sucked into the main tank 120 and recovered.

Subsequently, when the opening 33 of the nozzle 31 is placed closed to or in contact with the wall 150 (see Fig. 8) while maintaining the degree of suction vacuum of the fan motor 141 and the water pressure of the pump 132, just like in the case of Embodiment 1, the amount of outside air sucked into the nozzle 31 decreases as compared to that when the opening 33 of the nozzle 31 is unobstructed. The water 200 being expelled out of the fluid nozzle 12 overcomes the outside air 300 being sucked into the nozzle 31, and is ejected toward the wall 150. Then, the water 200 that has struck the wall 150 is sucked into the main tank 120 and recovered, together with the outside air 300, via the suction hose 101. If dirt or the like is adhering to the wall 150, just like in the case of Embodiment 1, the dirt will be removed by the water 200 being expelled on the wall 150 and will be sucked into the main tank 120 and recovered, together with the water 200 and the outside air 300, via the suction hose 101.

If the opening 33 of the nozzle 31 in the above condition is moved away

from the wall 150 (that is, the opening 33 of the nozzle 31 is unobstructed), the amount of outside air sucked into the nozzle 31 through its opening 33 again increases. In the area between the injection hole 17 of the fluid nozzle 12 and the opening 33 of the nozzle 31, the sucked-in outside air 300 collides with the water 200 being expelled out of the fluid nozzle 12. As a result, the outside air 300 overcomes the water 200 being expelled out of the fluid nozzle 12, and the water 200 is not ejected out of the opening 33 of the nozzle 31. Instead, the water 200 will be sucked into the main tank 120 and recovered, together with the outside air 300.

By using the nozzle 31 having the above-described structure, it is possible to expel the water 200 over a wide range of the wall 150, thereby enabling efficient suction operation.

Regarding Embodiment 2, the description has been given about the case in which the fan angle α of the fan-like part 35 was set to 115 degrees, the length of the long side of the opening 33 ("LS" in Fig. 9) was set to 100 mm, and the length of the short side of the opening 33 ("SS" in Fig. 9) was set to 4 mm. However, the fan angle, the length of the long side, and the length of the short side are not limited to the above settings, and can be decided as desired, according to the water pressure of the water 200 being expelled out of the fluid nozzle 12, as long as the following results are obtained: when the opening 33 of the nozzle 31 is unobstructed, the outside air 300 being sucked into the nozzle 31 through its opening 33 can overcome the pressure of the water 200 being expelled out of the fluid nozzle 12, and the water 200 can be sucked up together

with the outside air 300 without the water 200 being ejected out of the opening 33 of the nozzle 31; and when the opening 33 of the nozzle 31 is placed close to or in contact with the wall 150 to cause the amount of outside air sucked into the nozzle 31 to decrease, the water 200 being expelled out of the fluid nozzle 12 can overcome the pressure of the outside air 300 and is ejected toward the wall 150, and the water 200 that has struck the wall 150 can be sucked up.

Moreover, just like in the case of Embodiment 1, the attachment as shown in Fig. 6 can be placed, in an attachable and detachable manner, at the nozzle device 30 of Embodiment 2.